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Design and Analysis of Forging Component and Die

M.A. Khatode, S.V.Badnale, Y.N. ChateH.S.Deshmukh,Prof.M.N.Vaidya
(Mechanical EngineeringDepartment ,JSPM's,BSIOTRWagholi ,Pune,India)

Abstract: *This paper deals with the some of forging defects that occur in a forging company in the front arm suspension part. Due to this causes high rejection rates in the components and this paper describes the remedial measures that can reduce these defects in the hot forging. This part is used in the chassis of car. The study of issue was done with the help of quality assurance department within the industry. The various defects that occur in the components during forging are identified. The result of the study indicates that the rejection rate in the company was so much thanpercent of the total productions made each month. The defects in the forged component include mismatch, underfilling and bending of stem. Bending of stem of the component was the major problem which causes improper machining of component. This paper deals with the remedial actions that to be done to reduce the rejection rate. Simulation software is used to determine the deflection due to bending and hence helps to minimize on bending of stem of component. It is also concluded that the proper implementation of the proposed corrective plan reduces the rejection rate from 18 % to 5% .*
Keywords: *Hot forging,Forging defect remedies,controlling measures*

I. Introduction

Forging is the process which involves heating of metal and shaping the metal by plastic deformation by applying compressive forces.The compressive force may be in the form of hammer blows using a power hammer or a press. Forging refines the grain structure as well as improves the physical properties of the metal.The grain flow can be oriented in the direction of principal stressesencountered in actual use. Grain flow is thedirection of the pattern that the crystals takeduring plastic deformation. Physicalproperties (such as strength, ductility andtoughness) are much better in a forging thanin the base metal. Base metal has crystalsrandomly oriented.There are many imperfections that can beconsidered as being defects, ranging fromthose traceable to the raw materials tothose caused by one of the forging processesor by post forgingoperations. Defects can be are asimperfections that exceed certain limits. This article describes the study carriedout in a forging industry for remedial actions on defects to control them and to decrease the rejection rate.By investigating the component in the plant it is noted thatdefects are occurring in the forged parts causes high rejection rate, and the remedialactions or controlling measures that shouldbe taken to avoid these rejections.The various defects that occur in the components during forging are identified in the industry.The various defects in the forged components includes the lapping, mismatch, scales, quench cracks, under filling etc.[1]The major defects in the formation of under fills due to air pocket or improper filling of material between the forging and the tool, there is noinformation about modeling of such defects using FEA (Finite Element Analysis) software.[2] The software like ANSYS used for analysis of the componentTo investigate thevarious forging defects that occur in a forging industry that causes high rejection rates in the componentsand the remedial measures that can reduce these defects in the hot forging.[3]Forging process gives superior quality product compared to other manufacturing processes and we can produce number of parts with required mechanical properties.[4]

II. Problem Definition-

The defects occur in part (ARM FRONT SUSPENSION PART-LH) was the major problem in the industry.Main issue during forging of the component is" high rate of rejection due to non-acceptable steam surface that affecting the failure of machining process. " The fig2.1 shows the failure of machiningprocess, after the completion of forging process. We can see the unclean surface. Due to this, the company is suffering with high loss about this component. The cost of one forged component is 45 rupees. The cost of one complete machined product is 110 rupees. No. of jobs in scrap due to above problem in last two month is 3000.

The total economical loss = 110 x 3000 = 330,000

Fig.1 Defective job

With the help of quality department of company collection of rejection rate of the product is done whichis as follows,

Table 1 Rejection rate

MONTH	REJECTION RATE
MARCH- 2018	10%
APRIL- 2018	12%
MAY-2018	11.5%
JUNE-2018	14%
JULY-2018	14.3%
AUGUST -2018	17%
SEPTEMBER-2018	18.2%

1. Studies And Findings

Possible causes of the problem are as follows:

1. Under filling
2. Mismatch
3. Bending of stem of part
4. Incomplete forging penetration

Because of the above defects there was unclean machining on the job and hence rejection rate of the component was increasing.The defective fig is shown in the fig. 2.1. The Fig. 3.1 shoes the fishbone digrame of verios defects occure on forging process. The defects like mismatch, incomplet forging penetration, underfilling, bending of stem part shown in fig3.1. For this defects we will found the solutions.

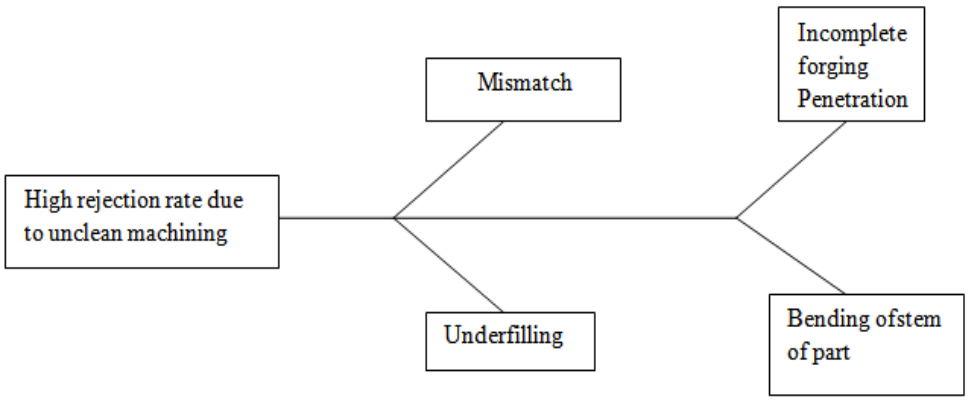

Fig. 2 Cause and defect Diagram

2. DIMENSIONAL ANALYSIS

CHECKING OF DIMENSIONS FOR FINDING MISMATCH

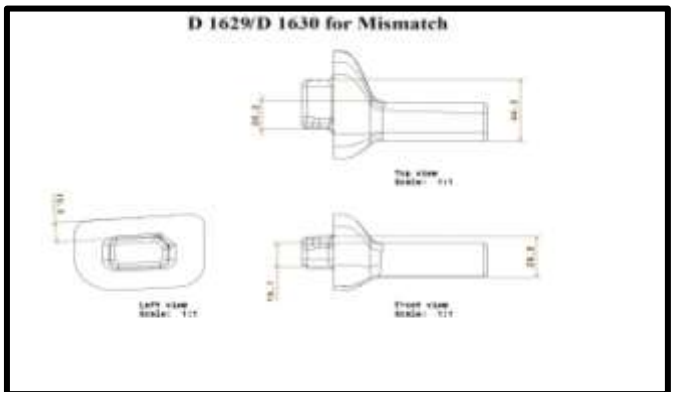

Fig. 3 Drawing for finding mismatch

By using above dimensions we can find the **mismatch** of the component. We use the **height gauge** to measuring the dimensions.

SAMPLE 1

Table 2

Basic Drawing Dimensions (mm)	Dimension Limit (mm)	Permissible Straightness Error (mm)	Actual Error (Mismatch) (mm)
19.1	18.97-19.23	0.26	0.13
29.8	31.1-29.06	2.04	1.3
20.5	22.13-20.44	1.69	**1.63**
44.2	44.97-44.44	0.53	0.77

SAMPLE 2

Table 2

Basic Drawing Dimensions (mm)	Dimension Limits (mm)	Permissible Straightness Error (mm)	Actual Error (Mismatch) (mm)
19.1	18.79-18.92	0.13	0.31
29.8	31.40-29.52	1.88	1.6
20.5	21.67-21.29	0.38	**1.17**
44.2	44.80-44.51	0.29	0.6

CHECKING OF DIMENSIONS FOR FINDING BEND

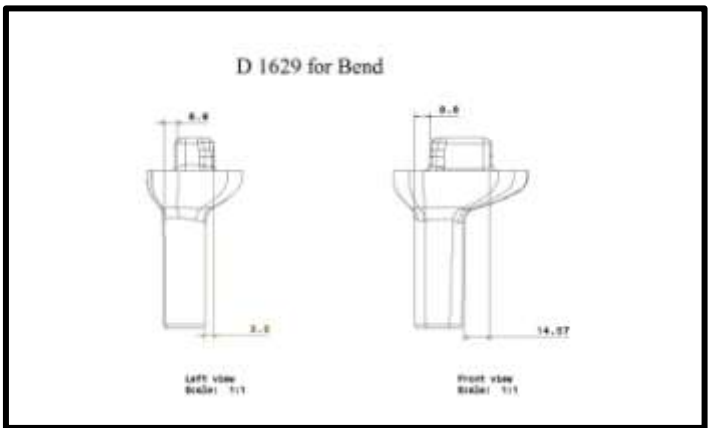

Fig. 4 Drawing for finding bend

By using above dimensions we measure the bend present in the steam. The above dimension provided by the design department. We use the height gauge for measuring the bend in component.

SAMPLE 1

Table 3

Drawing dimensions (mm)	Actual dimensions (mm)	Actual Bend Deviation (mm)
8.8	8.9	0.1
14.5	14.9	0.4
6.9	7.4	0.5
3.6	5.26	**1.66**

SAMPLE 2

Table 4

Drawing dimensions (mm)	Actual dimensions (mm)	Actual Bend Deviation (mm)
8.8	8.54	0.26
14.5	14.26	0.24
6.9	7.61	0.71
3.6	5.33	**1.73**

Dimensional analysis shows that the Bending is occur in the job in much more quantity. And theslightlymismatch is also produced during mismatch.

III. Part Drawing In CATIA Software

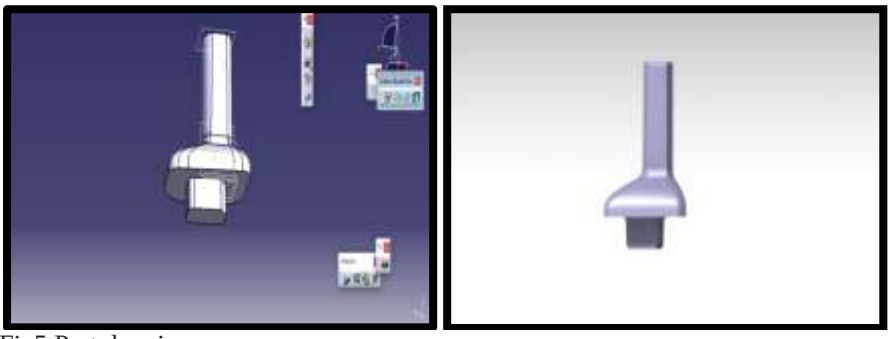

Fig5 Part drawing

fig. shows the part drawing prepared by the CATIA software as per the given dimensions .

IV. Simulation By Using ANSYS Workbench Software

Simulation of the forged part is done on the ANSYS software for finding bend or deflection in the stem of component where improper machining is happened.Simulation of the part for the various cases as follows and checking the deflection occurs in stem is done. In the ANSYS software we apply the various temperature conditions. In the 1st case we applying the 1158 ^{0}C temperature which is very high. In this temp the software shows the deflection near about 1.5 mm, which very high. At this temperature the component is red hot condition. In the 2nd conditions we reduce the temperature 1158 ^{0}C to 1000 ^{0}C by using the ANSYS software. At this condition the deflection isreduced from 1.5 mm to 0.8 mm. Again we reduced the temperature 1000 ^{0}C to 900 ^{0}C, at that time the deflection about the 0.2 mm.The 0.2 mm deflection at minimum temperature is negligible. From analysis of this ANSYS software we concluded that, when we reduce the temperature the deflection of the component also reduces. The result of the ANSYS software at different temperature with their deflection as shown below.

Case1. At 1158^0 C temperature

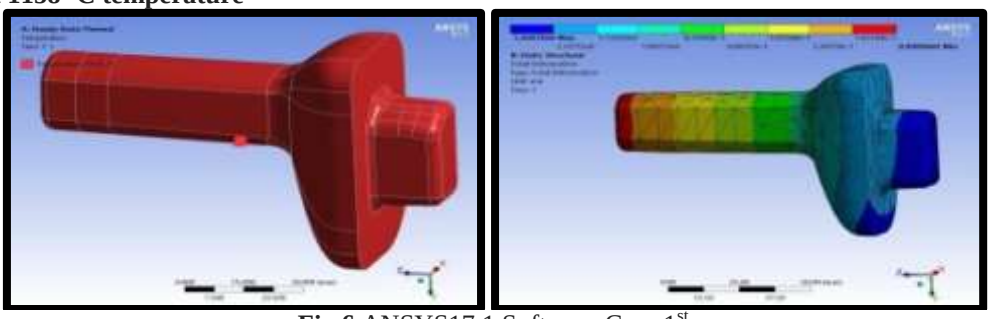

Fig.6 ANSYS17.1 Software Case 1st

Case 1 shows that there is **1.5mm** deflection in stem of part.

Case2.At 1000^0 C temperature

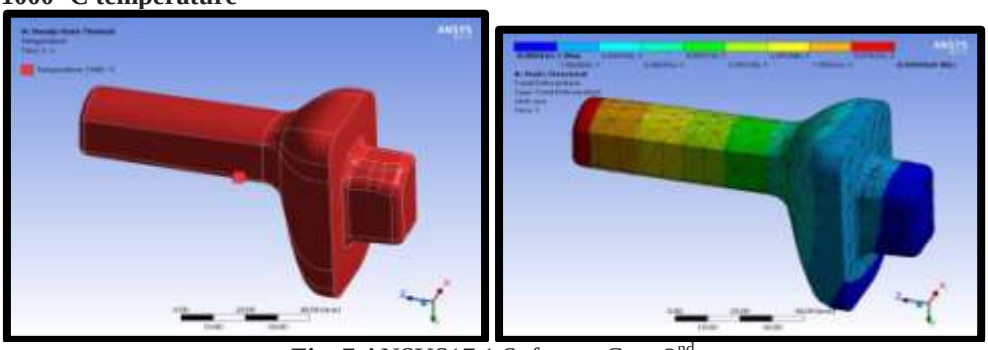

Fig. 7 ANSYS17.1 Software Case 2nd

Case 2 shows that there is **0.8 mm** deflection in stem of part**.**

Case3. At 900^{0}C temperature

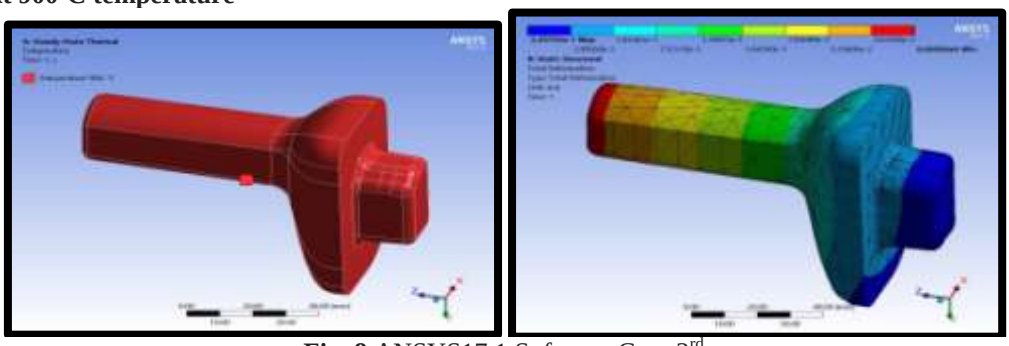

Fig. 8 ANSYS17.1 Software Case 3rd

Case 3 shows that there is **0.2 mm** deflection in stem of part which is very slight.

V. Accepted & Implemented Corrective Measures

1. Underfilling-

As there is underfilling in some of the jobs which are rejected. They are also contributing to high rejection rate. Underfilling is also one of the reason for the rejection of part.

Remedies –

Selection of suitable hydraulic forging press for manufacturing of part.

- Venting
- Grinding of die
- Proper die design
- Selecting suitable raw material
- Proper heating at suitable temperature

The accepting solution for this defect is slightly grinding the dies of component. Because of grinding there is proper flow of material to each and every corner of die and hence underfilling is avoided. The other remedies are already followed for the manufacturing of part in the company. The die is grinded near about 0.5mm.

Result–By using this corrective measure we can avoid this defects.

2. Mismatch-

Mismatch is also one of the defect which contributed to the high rejection rate.

Remedies-

- Suitable alignment of die halves.
- Make mistake proofing for proper alignment for Ex. Provide half notch on upper and lower die so that at the time of alignment notch will match each other.
- Tightening of nut bolt properly at proper time.

For this defect accepted solution is tightening of nut bolt properly at proper timing. If the frequency of nut bolt checking or repairing is less then the dies should remain in proper position without damaging and hence the mismatch problem can be reduced. The other solution is already accepted by the company for reducing the mismatch. By reducing the time of tightening of nut and bolts and doing proper alignment of dies this defect can be reduced.

Result- The defect is reduced by implementing the accepted solution.

3. Bending of stem of part-

Bending of the stem was the one of most major defect developed in the part. It was majorly contributing to high rejection rate of the product.

Remedies-

- Proper handling of part at high temperature.
- Proper cooling of part before its handling or reaching to billet.
- Use the conveyors to carry the job from press to billet

Accepting solution for the bending this defect was cooling the job to a particular temperature where bending should avoided or it should be negligible. For the solution of this defect application of conveyor is used. Chain conveyor is used to cool the job from 1158 ^{o}Cto 900 ^{o}C. As per the simulation done in ANSYS 17.1 software on the part shows that at 900 degree Celsius the deflection of the stem is 0.2 which is negligible. And hence the accepted solution reduced the bending of the steam.

Calculation-

24 jobs passing through conveyor in 1 minute.Weight of 1 job = **0.782kg**

Weight of 24 job = **24 x 0.782 =18.768 kg**

Total weight in one hour = **18.768 x 60 = 1126.08 kg/hr. = 1.126Tonne/hr**

Standard conveyor for above available capacity in the market is at cost of near about 2 lakhapproximately .They want immediate solution for reducing the demand and work load so there was no time for designing the conveyor. Solution for this problem was suggested that the company can use any conveyor which was available in company for cooling. And the suggestion works and bending was avoided by use of controlled cooling chain conveyor.

Result- The bending of stem of part is eliminated and machining is cleaned and neat steam surface produced.

4. Incomplete forging penetration-

Remedies-

- To use forging press for full penetration.
- Using press at proper speed and time.
- Tightening of nuts and bolts.

This is one of the defect which was responsible for some of part rejection. This is mainly caused due to using of undersized press for the part. And using improper load and speed of the press. Accepted solution for the defect was tightening of nut bolt in proper period and using the press at full load for the full penetration so that the defect can avoided and desired dimensions of the part can achieved.

Result- The defect is reduced by using accepted solution.

5. RESULT-

If there is some reduction in the temperature of job then it shows reduction in deflection and hence error in dimension is reduced. Therefore defect can be avoided.

Table 5 Temperature with respective Deflection

Sr. No.	Temperature(^{0}C)	Deflection(mm)
1	1158	1.50
2	1000	0.8
3	900	0.2

The above table different temperature along with their different deflection which is conducted ANSYS17.1. We can see that the maximum deflection present at maximum temperature. And the minimum deflection present at the minimum temperature.

The rejection rate is reduced from 18.2% to 8%

Table 6

MONTH	REJECTION RATE
MARCH- 2018	10%
APRIL- 2018	12%
MAY-2018	11.5%
JUNE-2018	14%
JULY-2018	14.3%
AUGUST -2018	17%
SEPTEMBER-2018	18.2%
NOVEMBER-2018	12%
DECEMBER-2018	9%
JANUARY-2019	8%

The table 6.2 shows month wise rejection rate that is March-2018 to January-2019. The fig 6.1 shows the graph of rejection rate between these months.

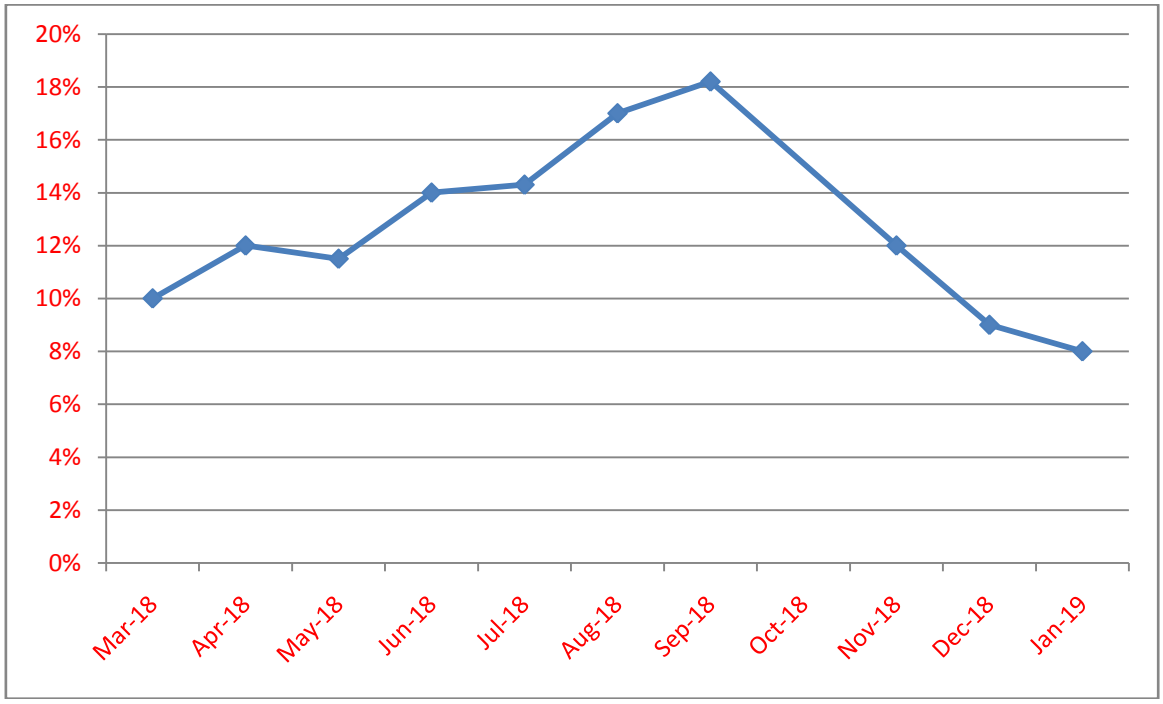

Fig.9 Graph of new rejection rate

The above graph shows the increase in the rejection rate in starting seven months that is March-18 to September-18 that causes the company is going in high financial losses. After that the company stop the production of that component (part). In October the company stop the production, after by adding corrective measure the rejection rate is reduced in next three months that is November-18 to January-19.

VI. Conclusion

1. The defects in forging like underfilling,mismatch etc. can be reduced by selecting proper corrective measures.
2. This rejection rate was reduced from 18% to 8% by implementing corrective measure & controlling or eliminating the defects.

3. By implementing the corrective measures the rejection rate will surely reduced.
4. By using proper conveyor system to handle or transport the job in red hot condition can definitely avoid deflection or bending in job.

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this paper.

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